PATENT DISCLOSURE

Inventor: Med Osman **Date: March 12, 2000**

Title: THE SQUARE ULTRA THRUST REVERSER SYSTEM

This patent is based on the previous US Patent # 5,615,834. The new thrust reverser system and particularly the door inner and outer skin design, shall be patented under the trade name of the **SQUARE ULTRA REVERSER.**

The **SQUARE ULTRA REVERSER** is a further adaptation of the innovative ideas of the **ULTRA THRUST REVERSER SYSTEM** to design a new lighter, more aerodynamically efficient and easier to manufacture thrust reverser system for aircrafts powered by fan or jet engines at a thrust level up to the low twenty thousand pound of thrust.

The **SQUARE ULTRA REVERSER** uses either a circular or rectangular cross-section for the Tailpipe. The Doors are designed with a flat inner skin to control the reversal process of the exhaust flow from the Jet Engine, in the proper direction along the direction of movement of the vehicle, away from control surfaces.

The design concept of both the **SQUARE ULTRA REVERSER** and the **ULTRA REVERSER,** are unique since they are based on having the reverser built on the Tailpipe. Other types of target thrust reversers such as the 4-Bar or the Single Pivot types are designed either around the tailpipe as is the case of the 4-Bar, or the reverser is the tailpipe as is the case of the Single Pivot design where the doors are an essential portion of the exhaust tailpipe system.

The innovative design concepts are:

1- **An integral exhaust tailpipe construction** which acts as the main structure carrying the various thrust reverser components and transmitting the loads to the engine bulkhead. As in the **ULTRA THRUST REVERSER SYSTEM,** it will consist of integral construction of the frames and the blister in the tailpipe skin to take the loads instead of having the frames as separate details riveted to the tailpipe. However, in the case of the **SQUARE ULTRA REVERSER,** the Tailpipe will be made in either a circular or rectangular cross-section.

   The integral construction will significantly reduce the manufacturing time and cost and result in a lighter and stronger tailpipe construction due to the fact that the hat section acts as two L-sections thereby providing twice as much rigidity as the traditional L-section used in the construction without incurring the weight penalty of a hat section. If acoustic attenuation is needed, specially for turbojet applications, the same process could be utilized where the bonded honeycomb will be sandwiched between an outer and an inner perforated tailpipe bonded together. The inner tailpipe skin will have the integral frames attached to the outer skin. The hat section areas will not have any perforations to enhance structural integrity. A strip of aluminum could also be welded to the hat sections in the

area exposed to the flow to enhance flow characteristics if needed, and/or the structural integrity of the tailpipe. Separate frames can be welded to the inner tailpipe skin, instead of the integral frames.

2- **Square integral construction of the clamshell doors** consisting of an outer aluminum skin and an inner flat skin that can handle high temperature gases, such as nickel based alloys or steel. The inner skin will be flat and have integral corrugations, two or more, depending on the loads, to replace the separate frames that are usually riveted to the outer and inner skins.

3- **The third innovative idea is the elimination of the fairings** on the side of the thrust reverser and the extension of the upper and lower doors outer and inner skins to cover the actuation mechanism in the stow position, as it was done with the **ULTRA THRUST REVERSER SYSTEM** . This approach will eliminate the cost of fabrication and tooling of the fairing as well as reducing the gaps which contribute to increase in drag and most importantly the control and containment of the reverse flow to keep it away from the aircraft control surfaces.

4- **The fourth innovative idea is the extension** of the inboard side of the upper and/or lower doors, as systems integration and compatibility demands, to further divert the exhaust flow in reverse away from the aircraft surface to enhance its stability on the ground during reverse thrust operation. The extension will be designed to underlap along the other door in the stow position along the actuation mechanism.

5- **The fifth innovative idea is the incorporation of movable surfaces** in the aft fairings, to control the Tailpipe exit area to optimize the Jet/Fan engine performance and directional control of the aircraft. From the side fairings and the top fairings, simple or compound control surfaces shall extend fore and/or aft, along guide tracks, thereby causing an increase/reduction in the exit area. These surfaces will be controlled by either hydraulic or other type of motion control, independent from the reverser operation.

OPERATION

The reverse thrust action occurs normally to slow down the aircraft during landing or for backing up and braking action during taxiing operations. When reverse thrust is commanded the clam shell doors will be unlocked and pushed back by the actuators, through linking mechanisms, behind the exhaust tailpipe exit area to direct the exhaust flow forward to slow down the aircraft from its landing speed down to a manageable taxiing speed.

The force resulting from the exhaust flow impingement on the doors shall be taken by the linkages mechanism which in turn dump the loads into the tailpipe integral frames and blister structures to the engine or nacelle bulkhead. Part of the load will also be imparted by the hydraulic actuator body thereby creating a redundant load path providing a fail safe design approach.

Boosted hydraulic pressure to the thrust reverser actuators shall reduce their respective diameters compared to current design approaches, thereby minimizing the impact of the internal blister, to

house the actuators system, on the engine exhaust gas path flow. The smaller actuators will eliminate the need for external blisters protruding in the free stream, thereby closely emulating the performance of the non-reversing tailpipe exhaust system. Fairings protruding in the free stream to cover the actuation system can cause a penalty of increased Specific Fuel Consumption (SFC) due to increased drag of up to 2% during normal cruise in addition to the other penalties caused by base drag, exhaust gas leakage from the tailpipe, gaps and increased weight compared to a non-reversing tailpipe configuration which can all add up to more than four percent increase in SFC.

The elimination of the fairings by extending the doors to cover the actuation system will favorably contribute to reduction in SFC penalty due to gaps between the fairings surfaces and the upper and lower doors and the extensive sealing required to minimize its impact on drag and aircraft performance. The SQUARE ULTRA REVERSER, similar to the ULTRA REVERSER, design minimizes the sealing requirements along the doors compared to all other designs and is much easier to seal since it is in a straight line, the fact that will render its impact on drag and sfc so insignificant and immeasurable.

The elimination of the fairings as well as the elimination of the other detail parts used in the traditional thrust reverser construction not only improves the aerodynamic performance of the thrust reverser system but also significantly contributes to the reduction of manufacturing and tooling design and also improves the overall system reliability due to the significant reduction of number of parts.

The movable fairings can be moved to slide forward or aft to increase/decrease the exit area, thereby optimizing the Jet/Fan engine thrust and fuel consumption. The convergent rectangular aft section of the SQUARE ULTRA REVERSER SYSTEM is similar to a rectangular conic shape, hence the motion of the movable fairings forward will lead to an increase in the exit geometric flow area, also the motion of the movable fairing aft will lead to a decrease of the geometric flow area, for the exhaust gases in the forward thrust mode of operation.

CLOSING STATEMENT

The SQUARE ULTRA REVERSER system provides a unique approach to the design of thrust reverser systems and doors, for aircrafts taking into consideration the forward thrust performance during the aircraft various modes of operation such as Take-off, Climb and Cruise which are critical for the aircraft range, climb and overall performance and marketability.

The design takes advantage of well developed, low risk manufacturing technology such as hydro-forming or super plastic forming to design integrally constructed components using conventional materials which is conducive to significant acquisition and maintenance cost reduction.

The new design which is extremely efficient, light, easy to manufacture, assemble and maintain will have significant impact on the aircraft and power plant performance for new as well as existing aircrafts that can be retrofitted with the new SQUARE ULTRA REVERSER.

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